INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT – STU-UNBLOCK

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.
Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for STU-Unblock applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The block signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The block frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to an unblock frequency, 100 hertz below the center frequency, and also increases the power output of the transmitter (from 1 watt to 10 watts).

CONSTRUCTION

The TCF receiver unit for STU Unblock applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. An input attenuator and a jack for metering the discriminator output current, are accessible from the front of the panel. See Fig. No. 14.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit board is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the position side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

L-C Filter (Wide Band Receivers Only)

From the attenuator, the signal passes through an L-C input filter FL-201. This filter has a relatively wide passband, and frequencies more than several hundred hertz above and below the center frequency (fc) of the channel are greatly attenuated while those less than several hundred hertz removed from the center frequency are passed with a minimum of attenuation. See Figure 4a. The purpose of the relatively wide band of the L-C filter is to minimize the channel delay time. This is generally recommended in STU-Unblock applications. However if the frequency spectrum is too crowded to permit the use of the wide band channel and a slower response time can be tolerated, then the narrow-band receiver using a crystal filter is recommended. This operation is described below.

Crystal Filter (Narrow Band Receivers Only)

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4b shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2 and for the discriminator output. The narrow pass band of FL2 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or cornona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of 20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (4 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is adjusted to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the center frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the unblock direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the block side of the discriminator center. It should be observed that although block frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the block frequency is 20 kHz-100 hertz. Similarly, the unblock frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

For use with a three frequency transmitter and a second receiver for transfer trip, the discriminator is adjusted opposite in sense to that described above for the standard STU-Unblock. That is, the discriminator is adjusted so that the block output is at 125 hertz below the zero output frequency instead of 125 hertz above while the unblock output is at 75 hertz above the zero output frequency This is shown in Figure 4C. Since the channel center frequency, fc, is at 100 hertz below the block frequency, the discriminator is thus adjusted for block output at fc + 100 hertz and unblock at fc + 300 hertz with zero output at fc + 225 hertz. Because of this requirement, the STU-Unblock receiver for three frequency operation can only be used with a wide band filter, FL201.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at block frequency and terminal 11 is at + 20 volts at unblock frequency. These two outputs feed the logic circuit board.

Logic Circuits

The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives block signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener Z104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through Z105, and its collector is held at approximately high voltage. Note that under this condition, input #1 to block D is supplied. If block signal should disappear but be followed promptly by appearance of unblock signal, the unblock input fed through R102 will not be diverted through D102 to the collector of Q103 but will flow through D101 to the base of Q102 to keep it conductive. However, if block signal disappears and unblock signal does not appear in approximately 150 ms. C102 will charge to the breakdown point of Z105, making Q103 conductive. TransistorQ103 becoming conductive causes transistor Q154 to become non-conducting and lets the voltage at pin 12 to rise high. This causes transistor Q181 to become non-conducting so that a "low" voltage appears at pin 8 of J3 indicating a <u>low signal</u> output. When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent unblock signal will be diverted through Q103 to negative instead of flowing through D101 and the base-emitter junction of Q102. If block signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of Z104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Block signal also produces input to transistor Q111 (block D). With base input to Q111 it has negligible voltage on its collector. With Q111 conducting, Q108 is prevented from becoming conducting so that no erroneous unblock signal can cause Q108 to become conducting as long as an unblock signal is being received. With Q108 non-conducting, Q184 is also non-conducting so that there is a "low" voltage output on pin 9 of J3. This "low" voltage is a <u>non-trip</u> condition of this Trip output.

When an unblock signal appears, input is fed to transistor Q106 through R119. Under this condition, Q106 becomes conducting causing Q183 to become conducting. This in turn causes a "high" voltage to appear at pin 12 of J3. This is the checkback signal.

The unblock signal also feeds an input through R102 into Q102. This causes Q102 to become conducting and Q103 to become non-conducting Now if Q111 is also non-conducting, meaning that there is no block signal present, then Q108 will become conducting. This in turn will cause Q184 to become conducting and a "high" voltage to appear at the Trip output (pin 9 of J3)

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either unblock or block signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from block to unblock by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of unblock signal has removed the input through R125.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the block signal and produce a discriminator output that no longer has a constant block output but rapidly fluctuates between block and unblock (and beyond). There will be relatively long periods when the discriminator has neither block nor unblock output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. If a fault should occur and unblock frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at unblock frequency minimizes such delay.

It should be noted that the checkback and the noise circuits are interconnected so that checkback cannot go "high" if there is a noise signal. That is, if there is an unblock signal causing Q106 to go conducting, then in the absence of noise signal, Q183 becomes conducting, causing a "high" voltage to appear at the checkback output (pin 12 of J3). However if there is a noise signal, Q107 becomes conducting. This causes Q182 to become conducting putting a "high" voltage on the Noise output (pin 6 of J3). Transistor Q182 conducting allows approximately 45 volts to appear at the junction point of R180, D183, and D182. This will cut off transistor Q183 preventing it from being conducting and thus preventing a "high" voltage from appearing at the checkback output (pin 12 of J3).

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, there is a low signal output alarm when there is absence of both block and unblock signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided by the carrier level indicator stage included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes D151 and D152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn on. This in turn will cause Q181 to become conducting and thus produce a "high" voltage at the Low Signal output (pin 8 of J3). This indicates the receipt of adequate carrier level and is a no low signal indicator. When the carrier signal deteriates to an inadequate level, transistors Q153, Q154, and Q181 will all become non-conducting and a "low" voltage will appear at the Low Signal output indicating loss of signal. The relative signal level at which this will occur is adjusted by means of R156 in the emitter circuit of transistor Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the input filter, but only by the level of the receiver input signal. The alarm will be activated in complete loss of signal or on loss of block signal if unblock signal does not appear within approximately 150 ms. After the alarm has been activated, the alarm will not be deactivated by subsequent appearance of unblock signal but only by the reappearance of Block signal. This is accomplished by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When block signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode D155. However, if the discriminator block output should fail because of a sufficeint frequency shift either above or below block frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through D155 and Q103 rather than entering the base of Q154. The later would become nonconductive and the alarm circuit would be activated even though the signal is unchanged. (A "low" voltage would appear at the Low Signal output indicating loss of signal.)

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With block signal being received, the signal level just below which the discriminator block output drops to zero is the minimum operating level of the receiver. The alarm should be activated at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15db. above the minimum operating level and set the alarm (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be activated when the indicator current dropped to slightly less than 0.5 ma.

In some applications, an alarm relay is supplied as well as a Low Signal output. This can be seen in Figure 2. In this case, the alarm relay coil is inserted on the output board in place of resistor R181. Now whenever Q154 becomes conducting, it not only makes Q181 conducting but also energizes the alarm relay.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting) (For crystal filter) 0.015 volt (55 db below 1 watt for limiting) (For L-C filter).
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter) (L-C filter)	down < 3 db at ± 220 hertz down > 60 db at ± 1000 hertz down < 3 db @ ± 300 hertz down > 40 db @ ± 1000 hertz
Discriminator	Set for 200 cycles shift from block to unblock frequency. Offset 25 hertz to favor block for all relay-output applications.
Operating time	9 ms. channel (transm. & recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105-140 V.D.C.
250 V.D.C.	210-280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator is made by the knob on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal block signal being received, input attenuator R5 should be adjusted to the position at which the low signal alarm drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION-Discriminator), the transmitter should be keyed to unblock transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip (unblock) output just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the Low signal and trip (unblock) output voltages just appear will be approximately the same, and the low signal minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the low signal just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has block output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156). Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the low signal again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of block frequency on the receiver input (R5 at zero), for narrow band receivers or 10 mv for wide band receivers, R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero). Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioraand permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5.A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantail reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as + 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Block or Unblock)
Q13	15	(Block or Unblock)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Block)
Q82	< 1	(No sig. or Block)
Q82	19.5	(Unblock)
Q101	< 1	(No sig. or Unblock)
Q101	7	(Block)
Q102	21	(No signal)
Q102	< 1	(Block or keyed unblock)
Q103	< 1	(No signal)
Q103	10	(Block or keyed unblock)
Q105	40	(No signal)
Q105	< 1	(Block or unblock)
Q106	15	(No Sig. or Block)
Q106	< 1	(Unblock)
Q107	< 1	(No sig. or Block)
Q107	15	(Unblock)
Q108	45	(No sig. or Block)
Q108	< 1	(Keyed Unblock)
Q111	15	(No. sig. or Unblock)
Q111	< 1	(Block)
Q151	6	(No signal)
Q151	6	(Block)
Q152	9.8	(No Signal)
Q152	10	(Block)
Q153	< 1	(No Signal)
Q153	19	(Block)
Q154	45	(No signal)
Q154	< 1	(Block)

Q181 through Q184-See truth table in Fig. 3.

– "Keyed Trip" signifies minimum transition time from Block to Unblock.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENTS

When the AL relay is supplied its contacts should be cleaned periodically. A contact burnisher S#182A838H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters hasbeen damaged.

Fig. 4 shows the –3db and –60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convencience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Input Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

A. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

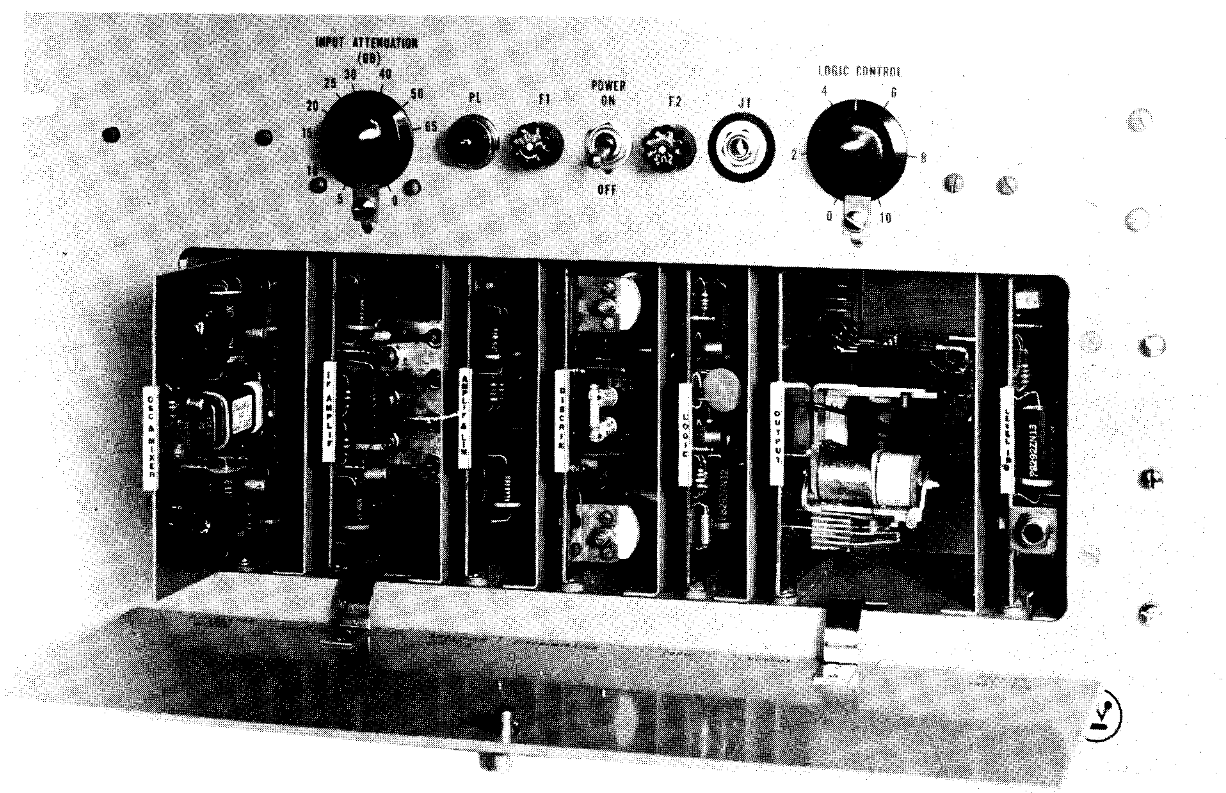
f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19'' rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.



Type TCF Receiver (Front View).

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ± 10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ± 10%; 1W.	188A302H10
CR109	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H05
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%: 10 W.	762A631H01
[illegible]	IN753A; 6.2 V. ± 5%; 400 MW.	862A606H0[illegible]

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 2%; Nickel Iron W.W.	09D8326G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±.5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

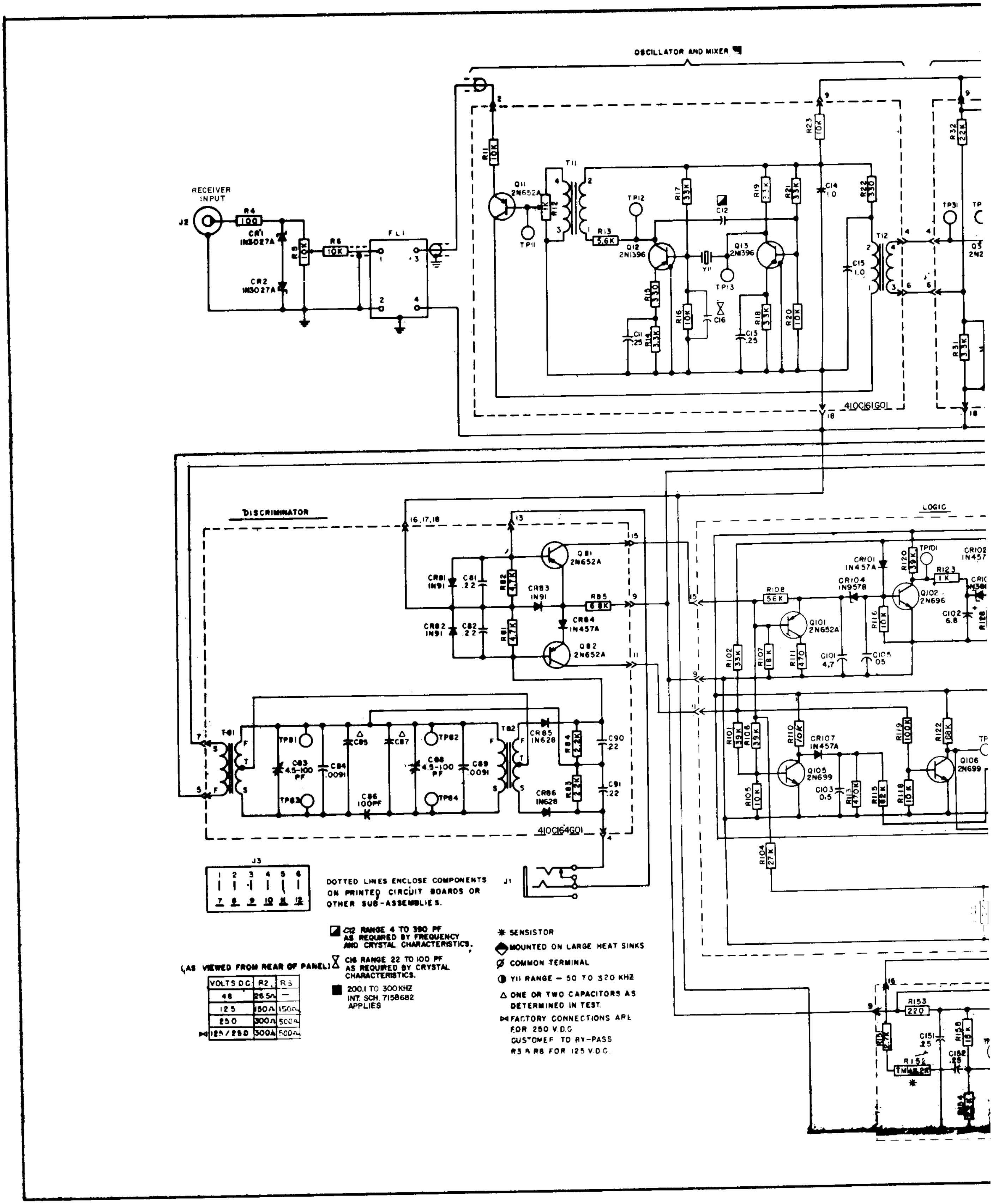
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K: 10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H03
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16

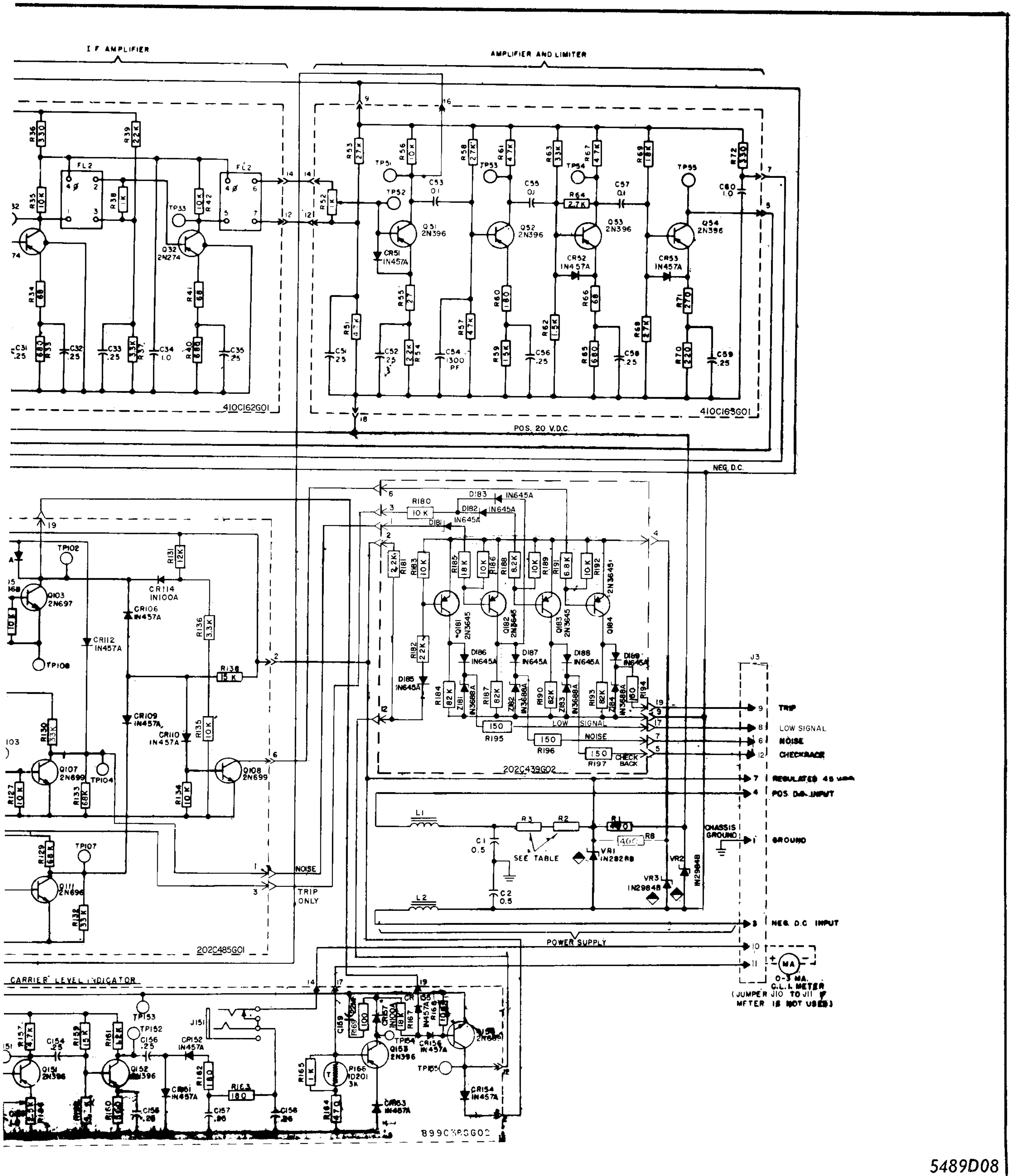
ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20kHz above Channel Frequency)	762A800H01 +(Req. Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04
FL201	LC Wide Band Input Filter	
	BUFFERED KEYING BOARD 202C516G03	
Q11	Transistor 2N4356	849A441H02
Q12	Transistor 2N699	184A638H19
Z11	Zener Diode 1N957B	186A797H06
Z12	Zener Diode 1N3688A	862A288H01
Z13	Zener Diode 1N3688A	862A288H01
Z14	Zener Diode 1N3686B	185A212H06
Z15	Zener Diode 1N3688A	862A288H01
C11	Capacitor .047 μ f,	849A437H04
R11	4.7K, ± 2%, ½ W Metal Glaze	629A531H48
R12	12K, ± 2%, ½ W Metal Glaze	629A531H58
R13	10K, ± 2%, ½ W Metal Glaze	629A531H56
R14	6.2K, ± 2%, ½ W Metal Glaze	629A531H51
R15	1.5K, ± 2%, ½ W Metal Glaze	629A531H36
R16	18K, ± 2%, ½ W Metal Glaze	629A531H62
R17	1.8K, ± 2%, ½ W Metal Glaze	629A531H38
R18	51K, ± 2%, ½ W Metal Glaze	629A531H73

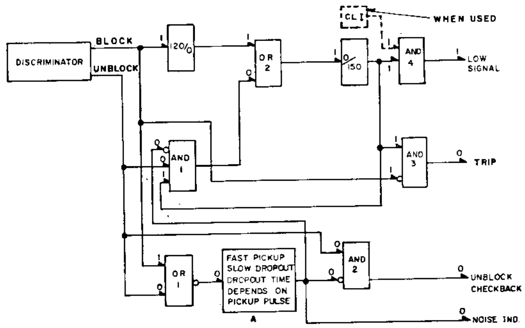


VOLTS DC	R2	R3
48	26.5Ω	—
125	150Ω	150Ω
250	300Ω	500Ω
125/250	300Ω	500Ω

Fig. 1. b) Internal schematic of the ty



…e TCF receiver for STU Unblock – Narrow Band



The d-c outputs of this TCF receiver should be as follows:

	CONDITION					
OUTPUT	1	2	3	4	5	6
Low Signal	20	0	0	20	0	20
Trip (Unblock)	0	0	0	20	0	0
Checkback	0	0	0	20	20	0
Noise	0	20	0	0	0	20

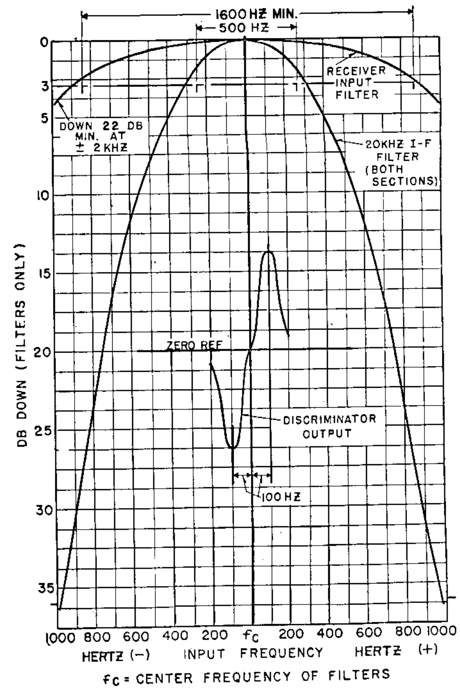
Description of Conditions:

1. Normal guard signal received.
2. Loss of channel (complete).*
3. Loss of channel (partial; CLI adjustment) or loss of d-c.
4. Trip (Unblock).
5. Trip signal after a complete loss of channel of over 150 ms.
6. Noise with guard or trip signal (S/N ratio 10 dB or less).

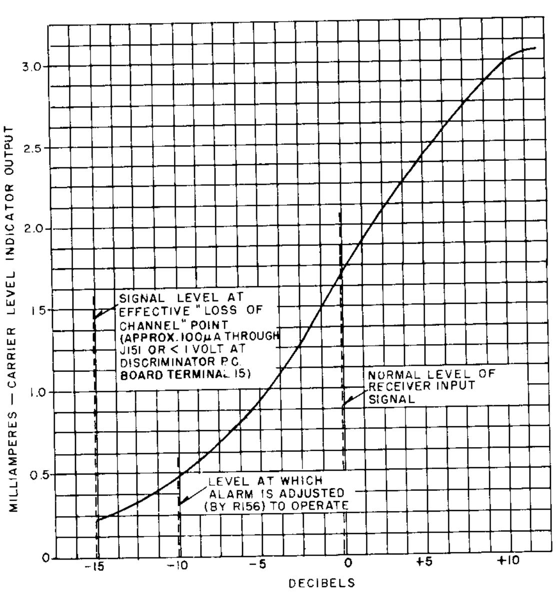
* NOTE: This receiver will give trip (Unblock) output for 150 ms for this condition.

876A058

Fig. 3 Block diagram of output logic circuit

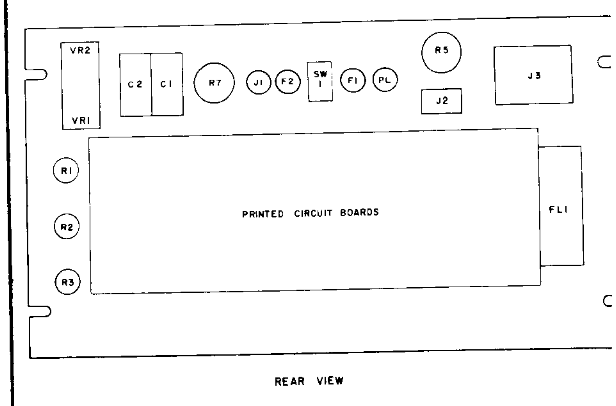


A 849A34



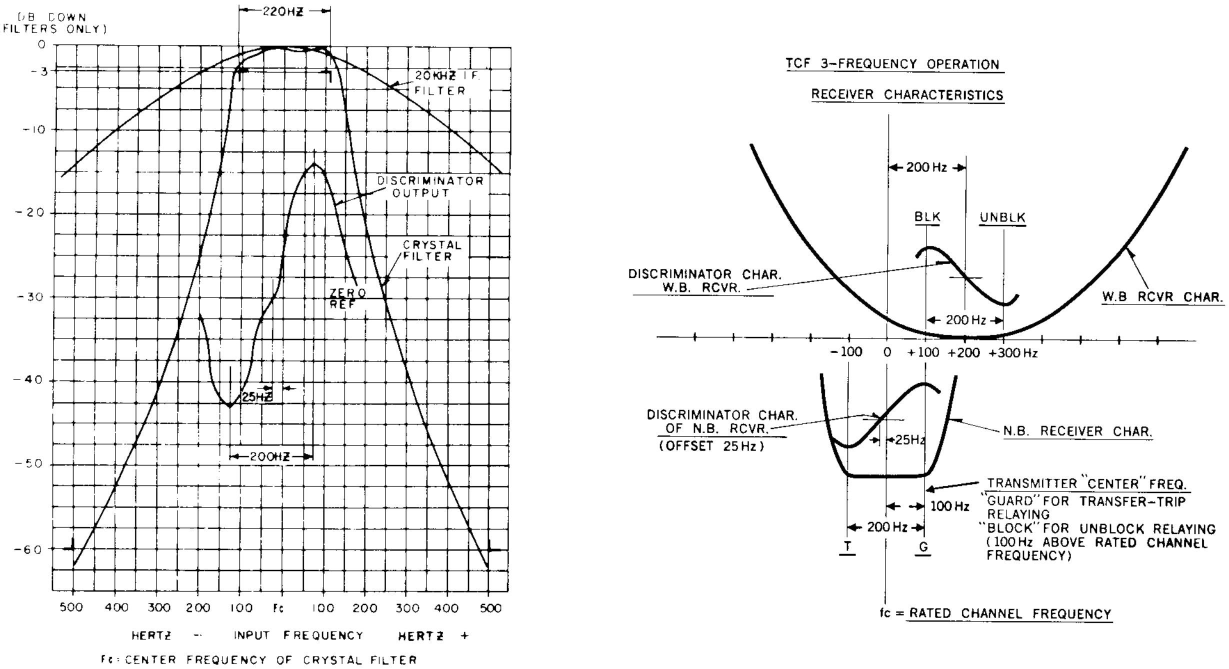
836A931

Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.



606B89

Fig. 6 Component locations on the type TCF receiver panel



B 836A932 C 880A986

Fig. 4 Filter and discriminator characteristics of the type TCF receiver

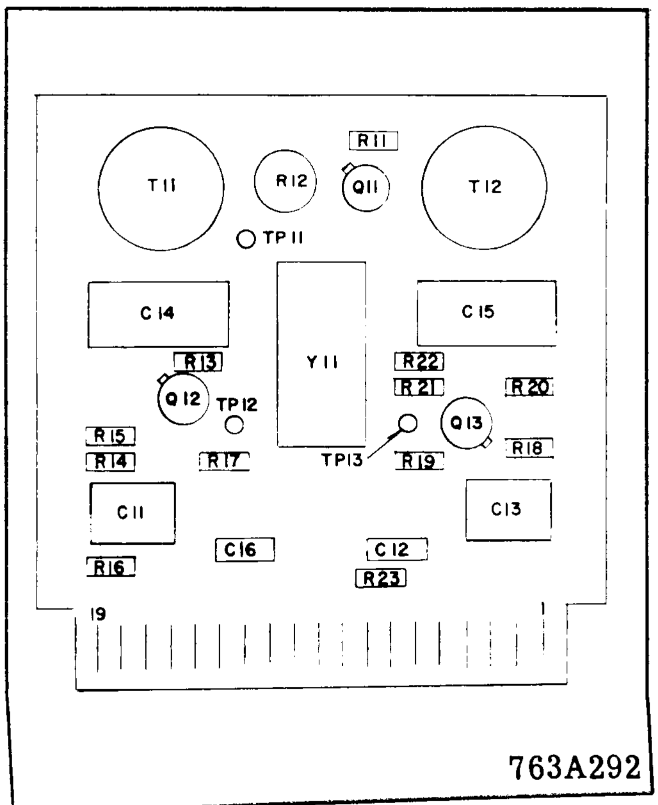


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

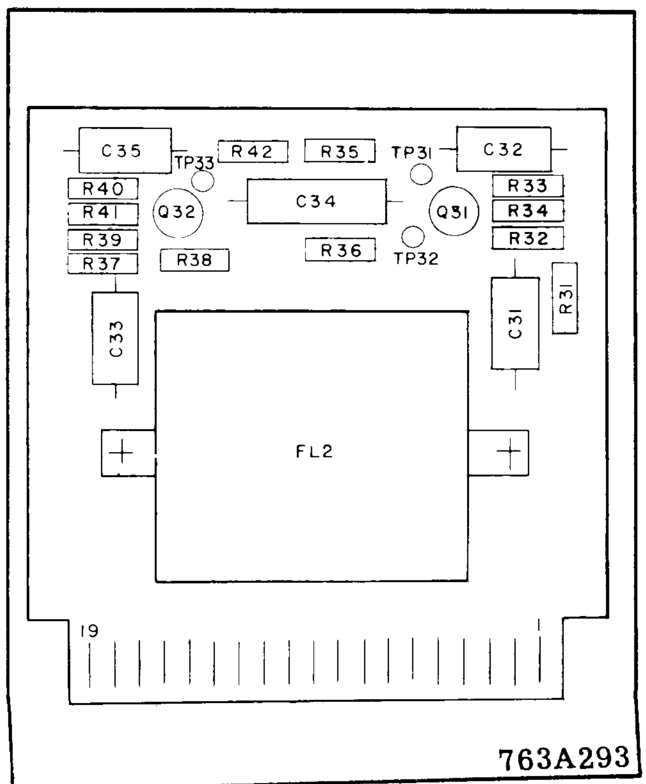


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

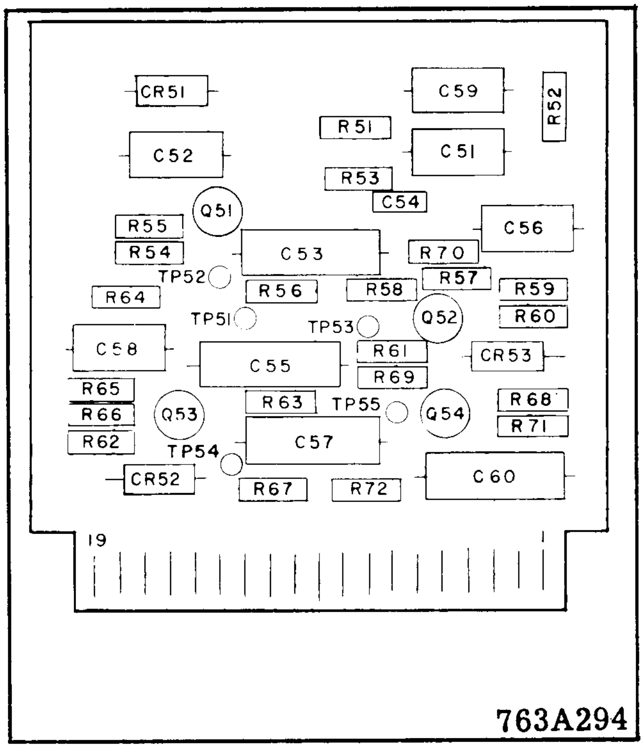


Fig. 9 **Component locations on the amplifier and limiter printed circuit board.**

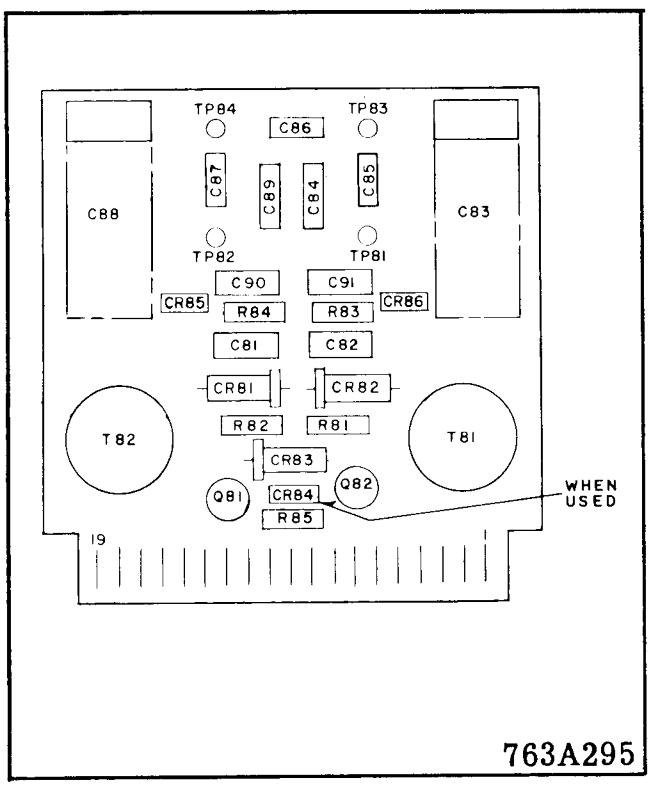


Fig. 10 **Component locations on the discriminator printed circuit board.**

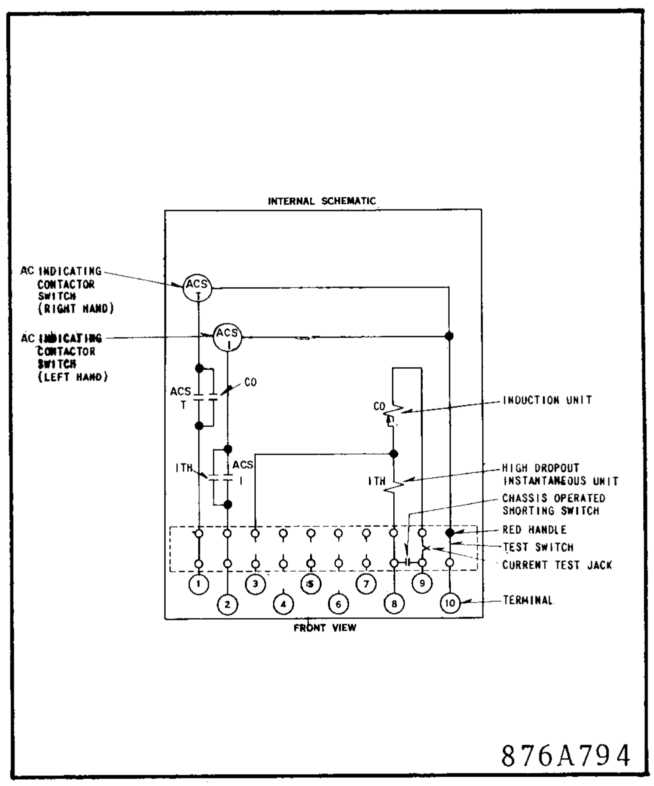


Fig. 11 **Component locations on the logic printed circuit board.**

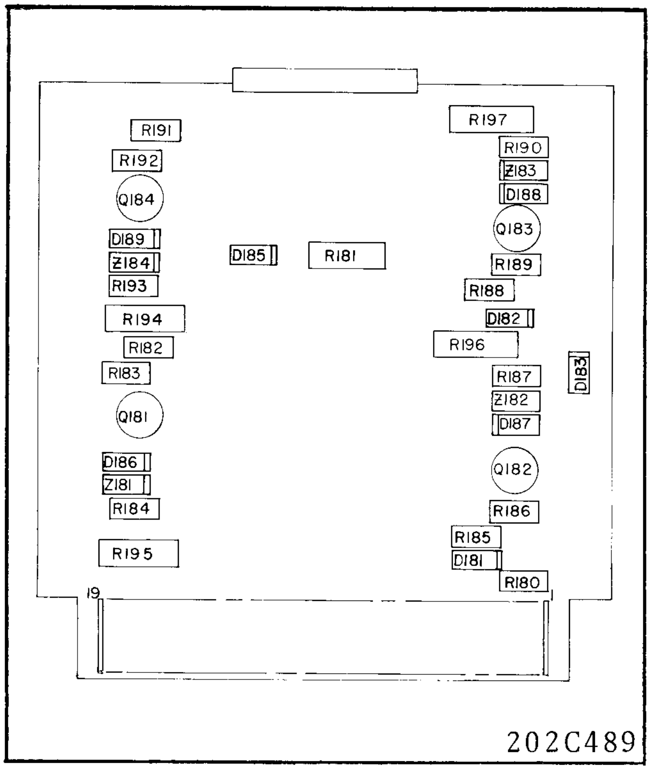


Fig. 12 Component locations on the output printed circuit board.

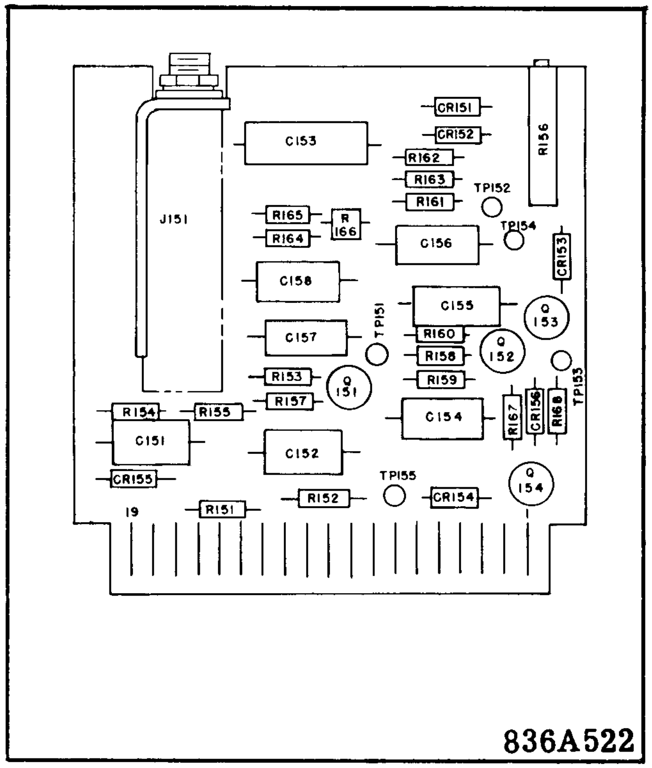


Fig. 13 Component locations on the carrier level indicator printed circuit board.

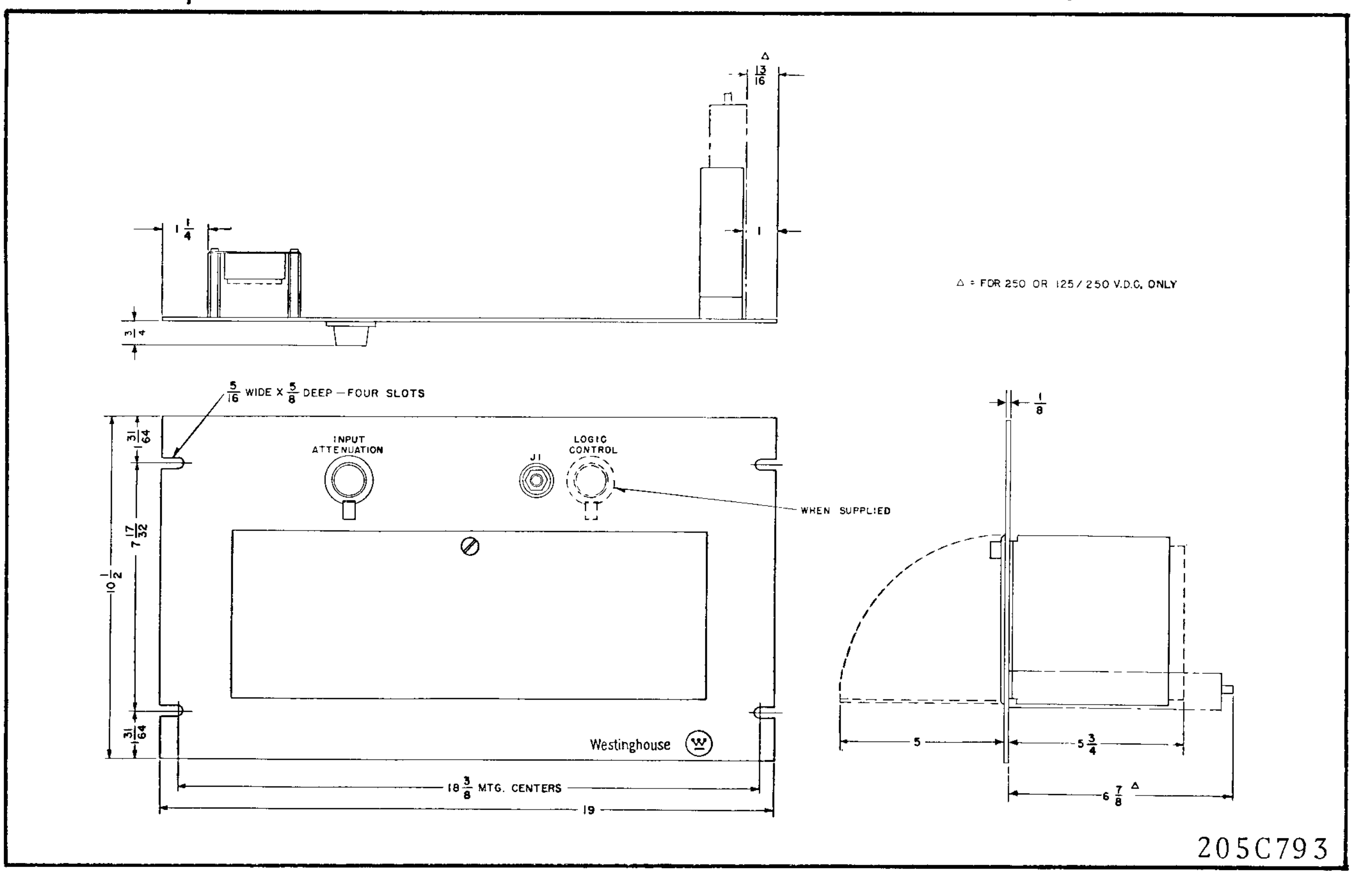


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

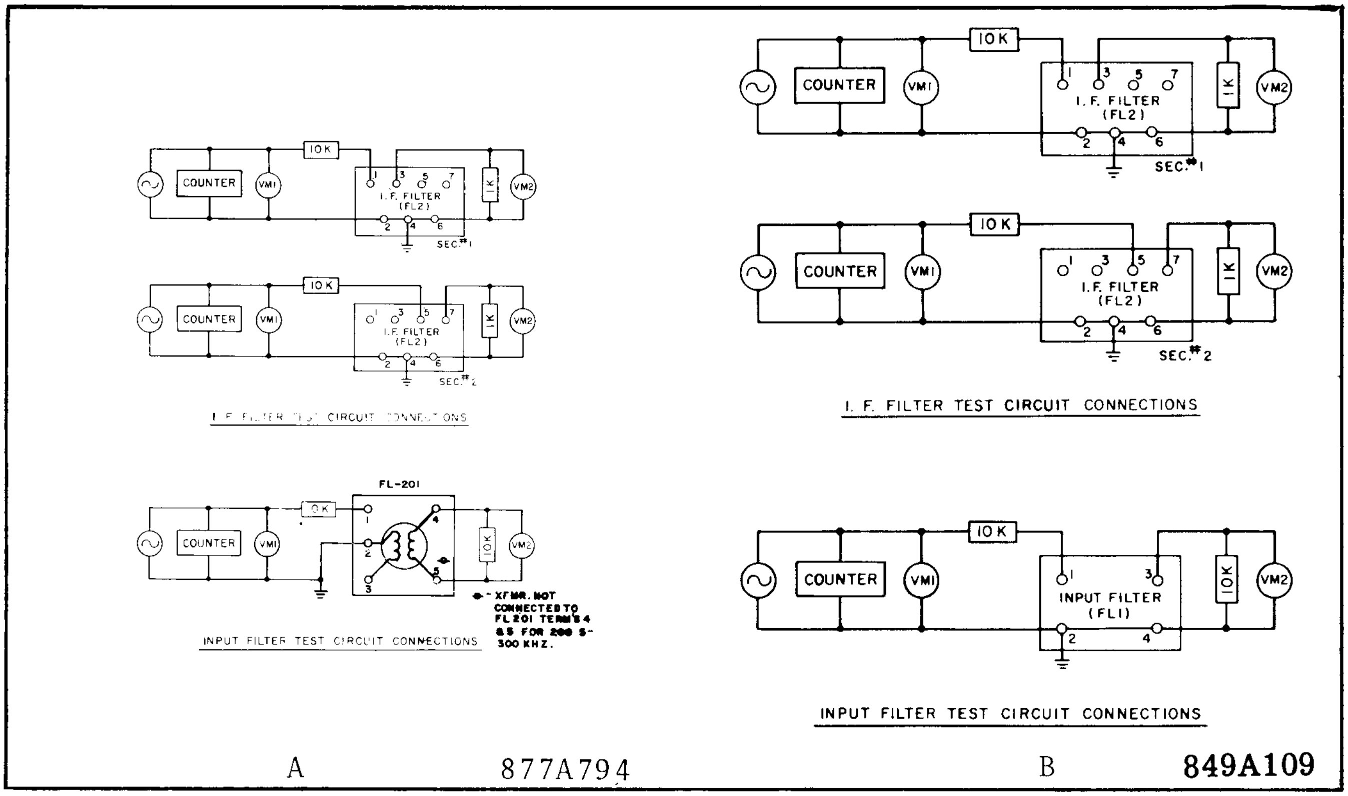


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

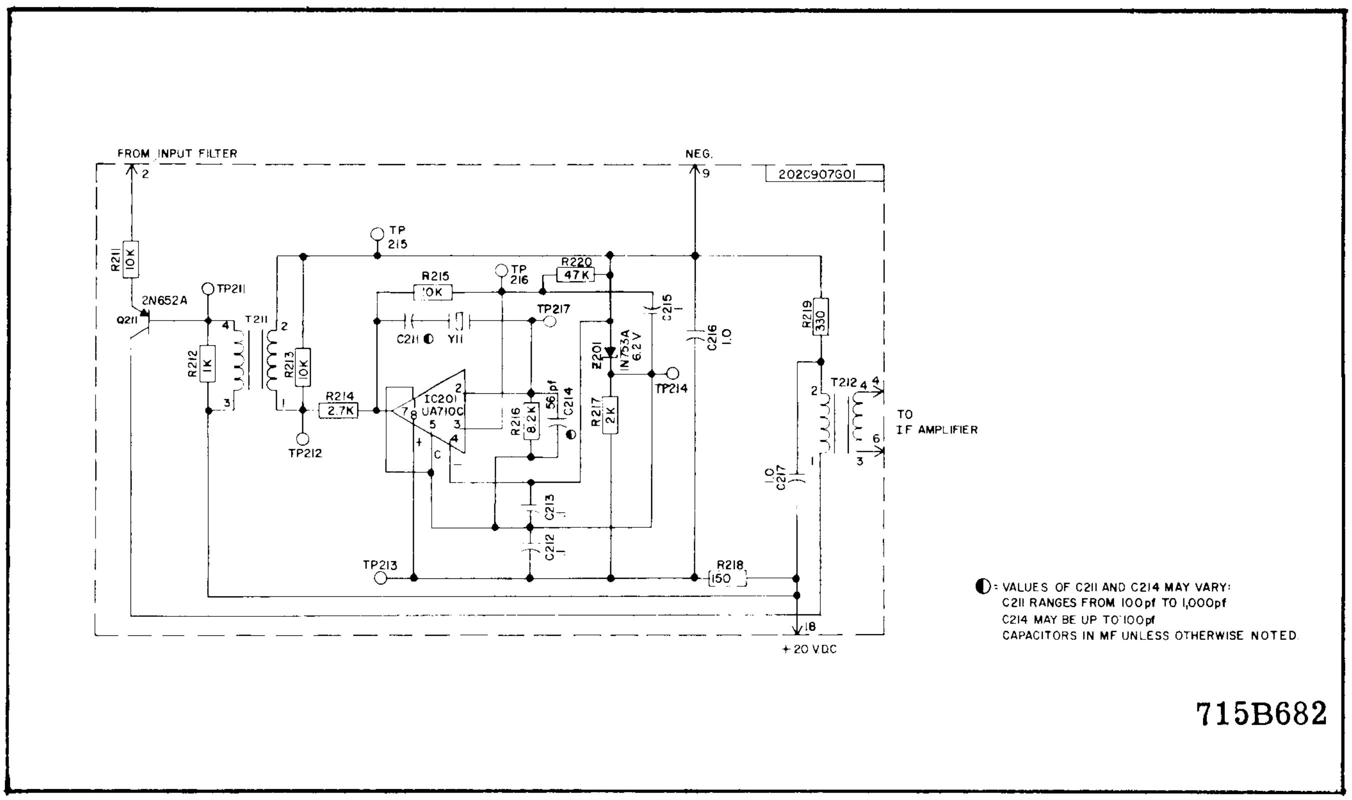


Fig. 16. 200.5 to 300 kHz oscillator mixer board

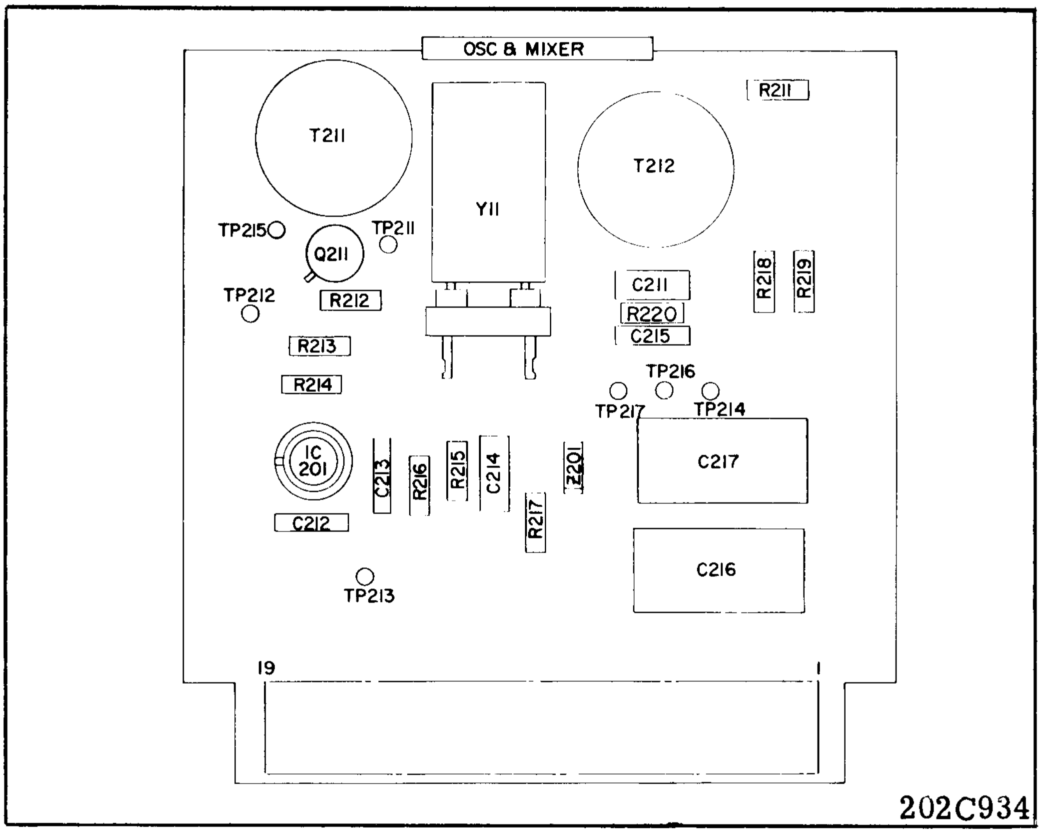
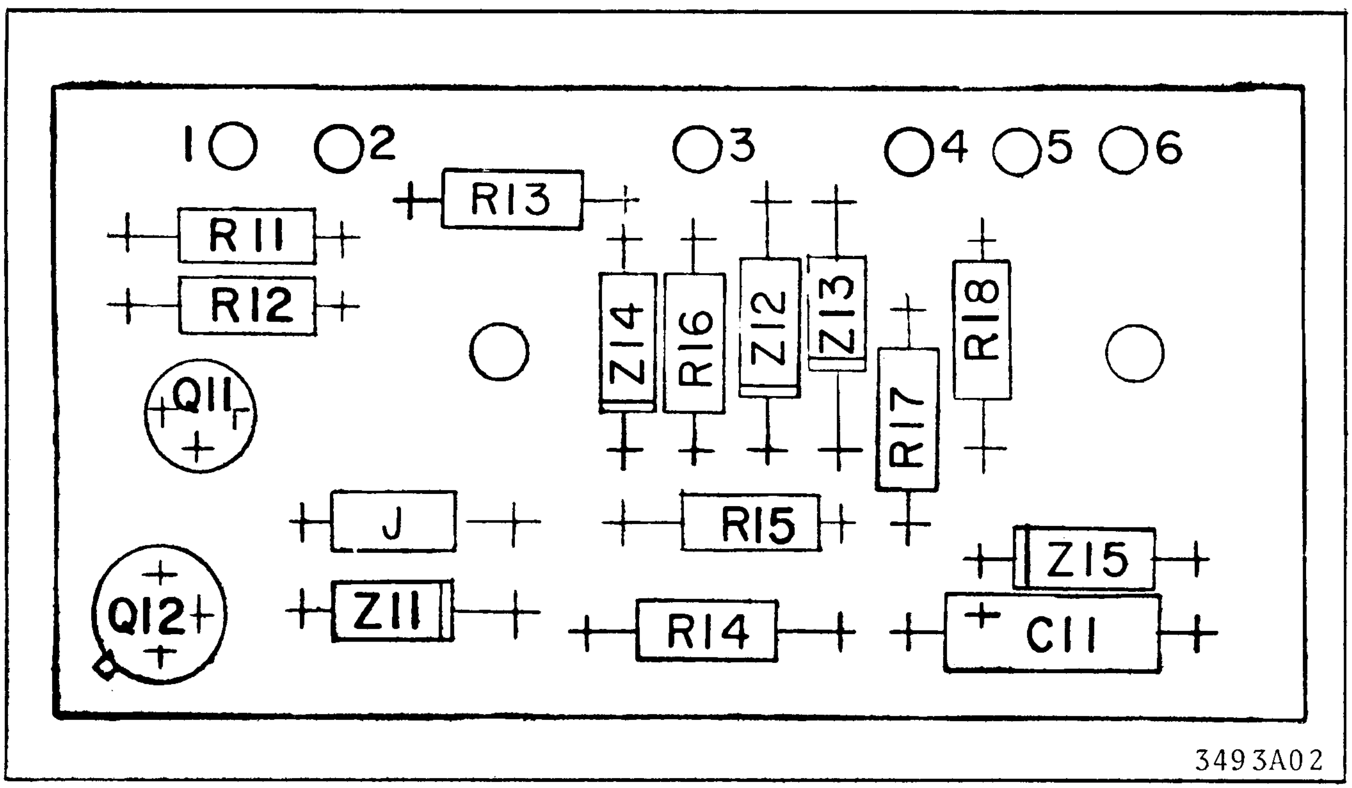


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT – STU-UNBLOCK

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.
Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for STU-Unblock applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The block signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The block frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to an unblock frequency, 100 hertz below the center frequency, and also increases the power output of the transmitter (from 1 watt to 10 watts).

CONSTRUCTION

The TCF receiver unit for STU Unblock applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. An input attenuator and a jack for metering the discriminator output current, are accessible from the front of the panel. See Fig. No. 14.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit board is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the position side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

When an unblock signal appears, input is fed to transistor Q106 through R119. Under this condition, Q106 becomes conducting causing Q183 to become conducting. This in turn causes a "high" voltage to appear at pin 12 of J3. This is the checkback signal.

The unblock signal also feeds an input through R102 into Q102. This causes Q102 to become conducting and Q103 to become non-conducting Now if Q111 is also non-conducting, meaning that there is no block signal present, then Q108 will become conducting. This in turn will cause Q184 to become conducting and a "high" voltage to appear at the Trip output (pin 9 of J3)

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either unblock or block signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from block to unblock by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of unblock signal has removed the input through R125.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the block signal and produce a discriminator output that no longer has a constant block output but rapidly fluctuates between block and unblock (and beyond). There will be relatively long periods when the discriminator has neither block nor unblock output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. If a fault should occur and unblock frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at unblock frequency minimizes such delay.

It should be noted that the checkback and the noise circuits are interconnected so that checkback cannot go "high" if there is a noise signal. That is, if there is an unblock signal causing Q106 to go conducting, then in the absence of noise signal, Q183 becomes conducting, causing a "high" voltage to appear at the checkback output (pin 12 of J3). However if there is a noise signal, Q107 becomes conducting. This causes Q182 to become conducting putting a "high" voltage on the Noise output (pin 6 of J3). Transistor Q182 conducting allows approximately 45 volts to appear at the junction point of R180, D183, and D182. This will cut off transistor Q183 preventing it from being conducting and thus preventing a "high" voltage from appearing at the checkback output (pin 12 of J3).

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, there is a low signal output alarm when there is absence of both block and unblock signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided by the carrier level indicator stage included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes D151 and D152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn on. This in turn will cause Q181 to become conducting and thus produce a "high" voltage at the Low Signal output (pin 8 of J3). This indicates the receipt of adequate carrier level and is a no low signal indicator. When the carrier signal deteriates to an inadequate level, transistors Q153, Q154, and Q181 will all become non-conducting and a "low" voltage will appear at the Low Signal output indicating loss of signal. The relative signal level at which this will occur is adjusted by means of R156 in the emitter circuit of transistor Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the input filter, but only by the level of the receiver input signal. The alarm will be activated in complete loss of signal or on loss of block signal if unblock signal does not appear within approximately 150 ms. After the alarm has been activated, the alarm will not be deactivated by subsequent appearance of unblock signal but only by the reappearance of Block signal. This is accomplished by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When block signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode D155. However, if the discriminator block output should fail because of a sufficeint frequency shift either above or below block frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through D155 and Q103 rather than entering the base of Q154. The later would become nonconductive and the alarm circuit would be activated even though the signal is unchanged. (A "low" voltage would appear at the Low Signal output indicating loss of signal.)

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With block signal being received, the signal level just below which the discriminator block output drops to zero is the minimum operating level of the receiver. The alarm should be activated at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15db. above the minimum operating level and set the alarm (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be activated when the indicator current dropped to slightly less than 0.5 ma.

In some applications, an alarm relay is supplied as well as a Low Signal output. This can be seen in Figure 2. In this case, the alarm relay coil is inserted on the output board in place of resistor R181. Now whenever Q154 becomes conducting, it not only makes Q181 conducting but also energizes the alarm relay.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting) (For crystal filter) 0.015 volt (55 db below 1 watt for limiting) (For L-C filter).
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at ± 220 hertz down > 60 db at ± 1000 hertz
(L-C filter)	down < 3 db @ ± 300 hertz down > 40 db @ ± 1000 hertz
Discriminator	Set for 200 cycles shift from block to unblock frequency. Offset 25 hertz to favor block for all relay-output applications.
Operating time	9 ms. channel (transm. & recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105-140 V.D.C.
250 V.D.C.	210-280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½'' or 6 r.u. Panel width - 19''
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator is made by the knob on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal block signal being received, input attenuator R5 should be adjusted to the position at which the low signal alarm drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION-Discriminator), the transmitter should be keyed to unblock transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip (unblock) output just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the Low signal and trip (unblock) output voltages just appear will be approximately the same, and the low signal minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the low signal just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has block output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156). Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the low signal again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of block frequency on the receiver input (R5 at zero), for narrow band receivers or 10 mv for wide band receivers, R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero). Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deteriora- and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5.A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantail reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as + 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Block or Unblock)
Q13	15	(Block or Unblock)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Block)
Q82	< 1	(No sig. or Block)
Q82	19.5	(Unblock)
Q101	< 1	(No sig. or Unblock)
Q101	7	(Block)
Q102	21	(No signal)
Q102	< 1	(Block or keyed unblock)
Q103	< 1	(No signal)
Q103	10	(Block or keyed unblock)
Q105	40	(No signal)
Q105	< 1	(Block or unblock)
Q106	15	(No Sig. or Block)
Q106	< 1	(Unblock)
Q107	< 1	(No sig. or Block)
Q107	15	(Unblock)
Q108	45	(No sig. or Block)
Q108	< 1	(Keyed Unblock)
Q111	15	(No. sig. or Unblock)
Q111	< 1	(Block)
Q151	6	(No signal)
Q151	6	(Block)
Q152	9.8	(No Signal)
Q152	10	(Block)
Q153	< 1	(No Signal)
Q153	19	(Block)
Q154	45	(No signal)
Q154	< 1	(Block)

Q181 through Q184-See truth table in Fig. 3.

– "Keyed Trip" signifies minimum transition time from Block to Unblock.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENTS

When the AL relay is supplied its contacts should be cleaned periodically. A contact burnisher S#182A838H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters hasbeen damaged.

Fig. 4 shows the –3db and –60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convencience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Input Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

A. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

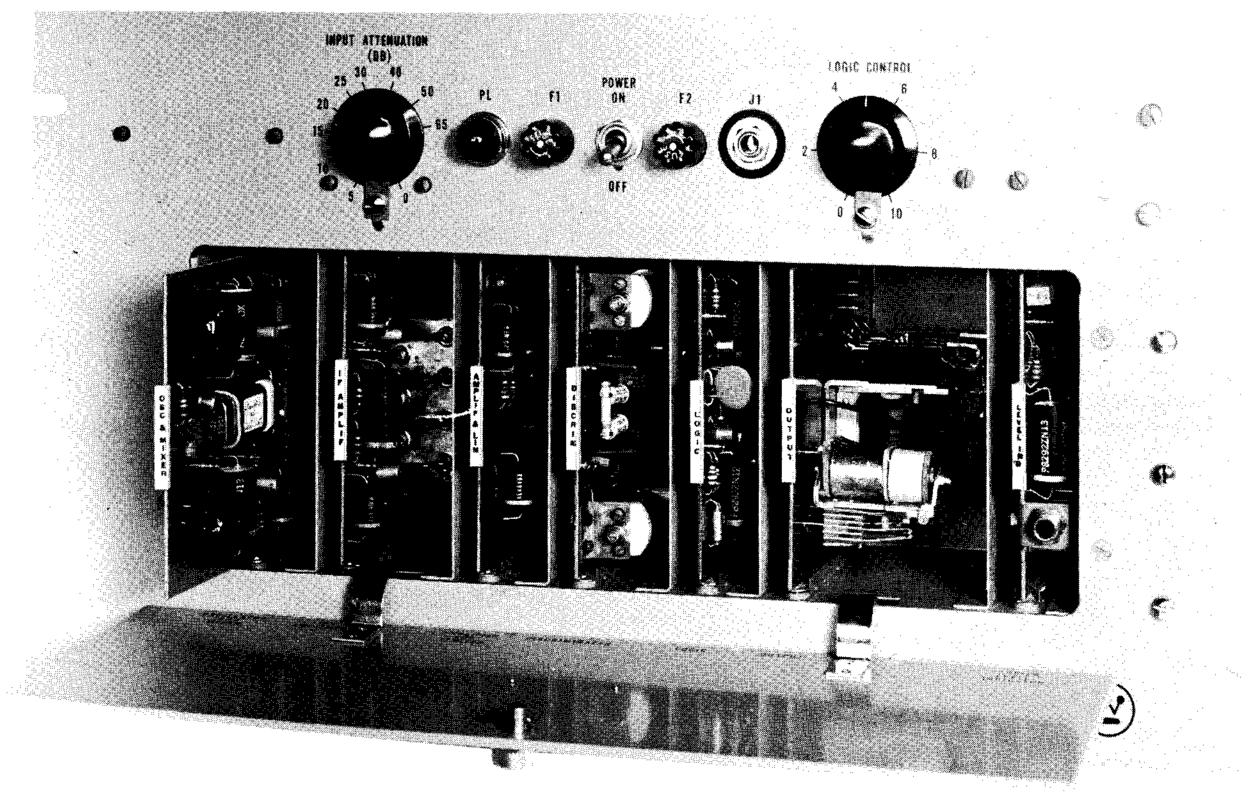
f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19'' rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.



Type TCF Receiver (Front View).

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ± 10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ± 10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 2%; Nickel Iron W.W.	09D8326G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K: 10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H03
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
MISCELLANEOUS		
Y11	Oscillator Crystal (Frequency 20kHz above Channel Frequency)	762A800H01 +(Req. Freq.)
FL1	Crystal input Filter	401C466 + (Reg. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04
FL201	LC Wide Band Input Filter	
BUFFERED KEYING BOARD 202C516G03		
Q11	Transistor 2N4356	849A441H02
Q12	Transistor 2N699	184A638H19
Z11	Zener Diode 1N957B	186A797H06
Z12	Zener Diode 1N3688A	862A288H01
Z13	Zener Diode 1N3688A	862A288H01
Z14	Zener Diode 1N3686B	185A212H06
Z15	Zener Diode 1N3688A	862A288H01
C11	Capacitor .047 μ f,	849A437H04
R11	4.7K, ± 2%, ½ W Metal Glaze	629A531H48
R12	12K, ± 2%, ½ W Metal Glaze	629A531H58
R13	10K, ± 2%, ½ W Metal Glaze	629A531H56
R14	6.2K, ± 2%, ½ W Metal Glaze	629A531H51
R15	1.5K, ± 2%, ½ W Metal Glaze	629A531H36
R16	18K, ± 2%, ½ W Metal Glaze	629A531H62
R17	1.8K, ± 2%, ½ W Metal Glaze	629A531H38
R18	51K, ± 2%, ½ W Metal Glaze	629A531H73

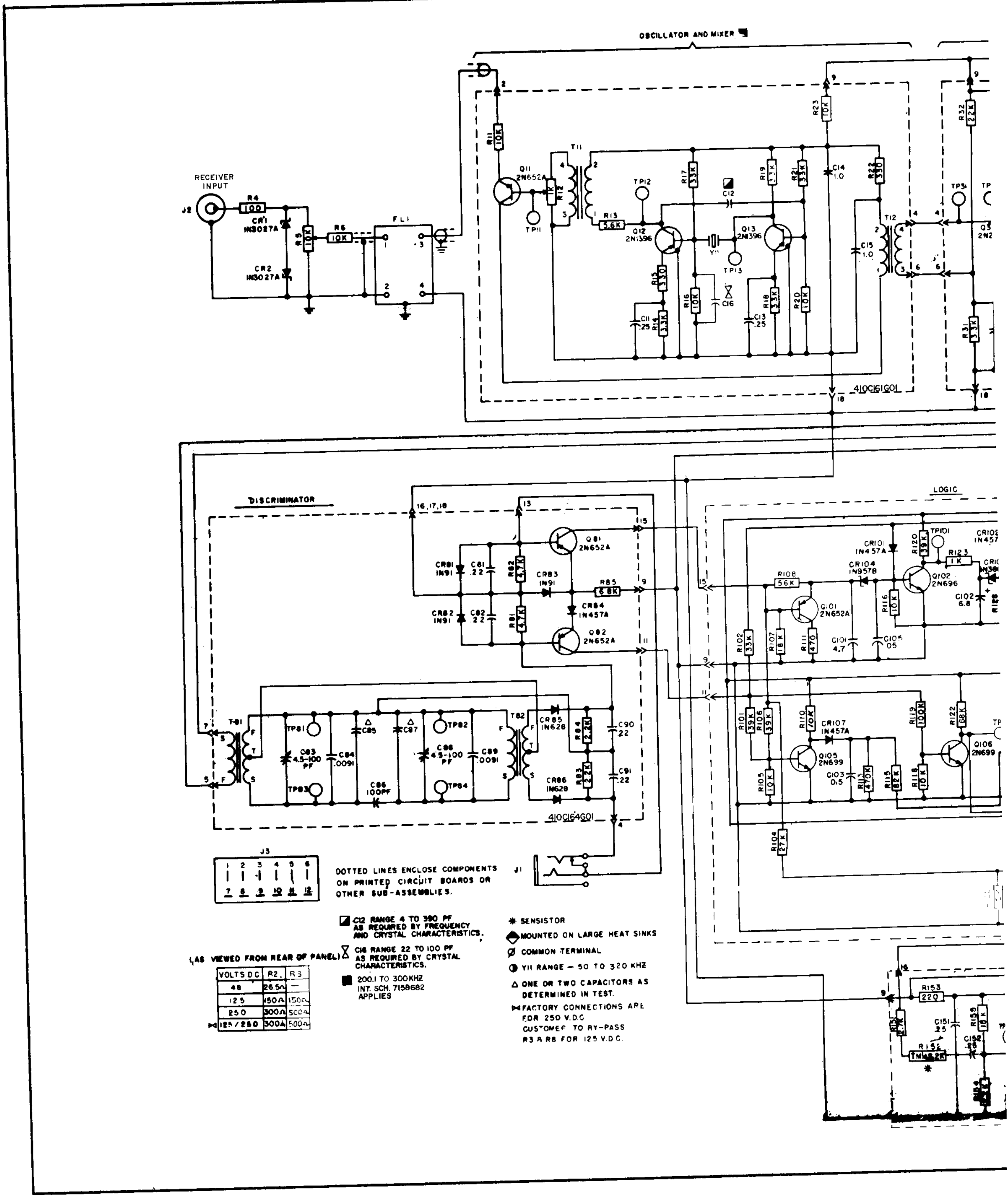
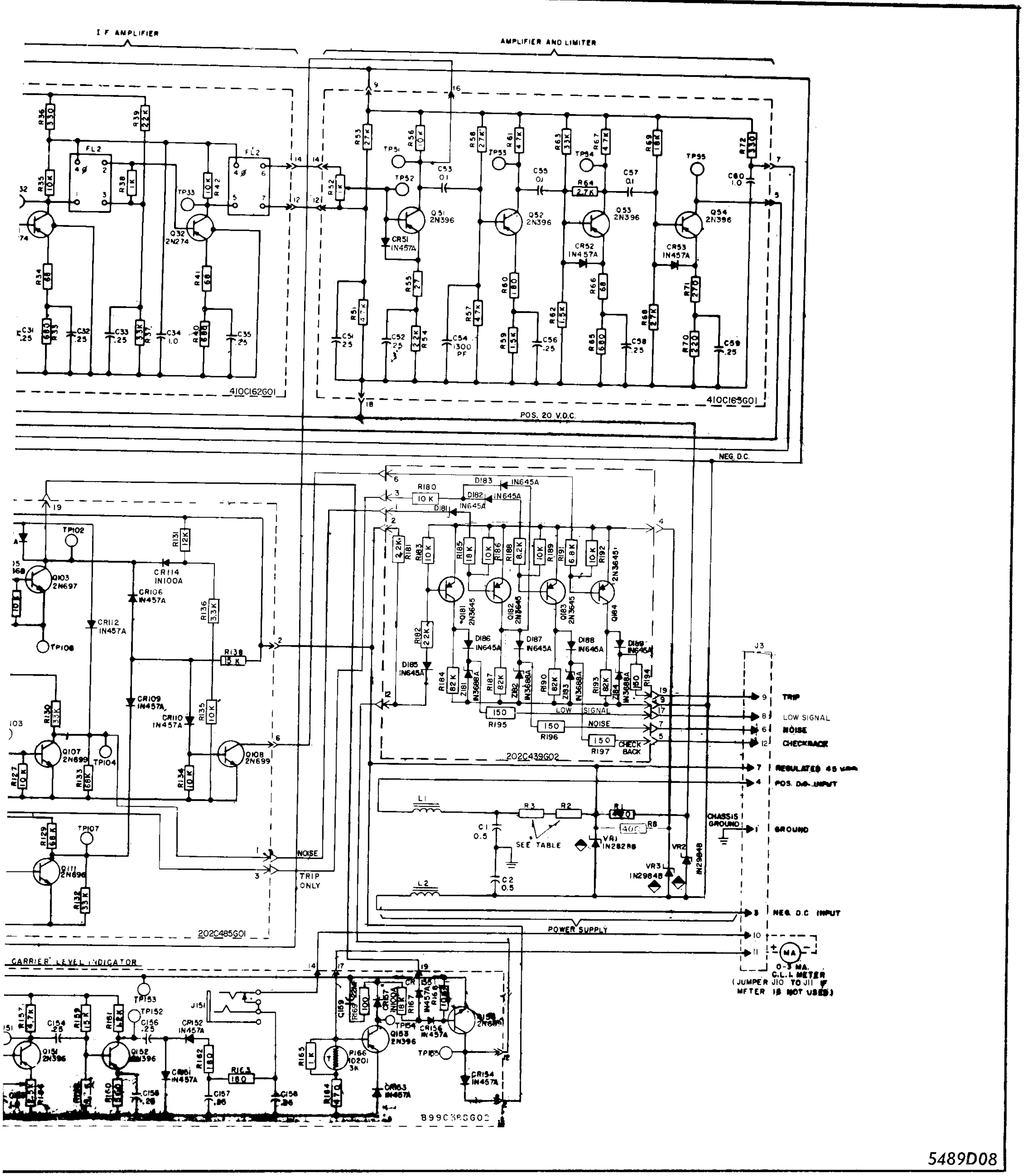
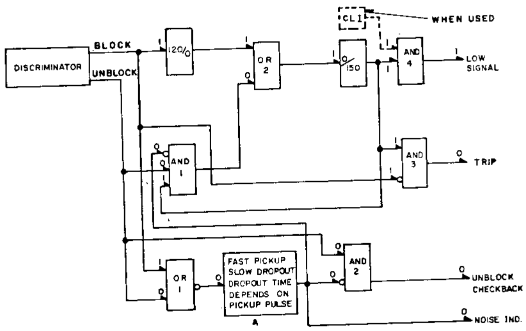


Fig. 1. b) Internal schematic of the ty



›e TCF receiver for STU Unblock – Narrow Band



The d-c outputs of this TCF receiver should be as follows:

	CONDITION					
OUTPUT	1	2	3	4	5	6
Low Signal	20	0	0	20	0	20
Trip (Unblock)	0	0	0	20	0	0
Checkback	0	0	0	20	20	0
Noise	0	20	0	0	0	20

Description of Conditions:

1. Normal guard signal received.
2. Loss of channel (complete).*
3. Loss of channel (partial; CLI adjustment) or loss of d-c.
4. Trip (Unblock).
5. Trip signal after a complete loss of channel of over 150 ms.
6. Noise with guard or trip signal (S/N ratio 10 dB or less).

* NOTE: This receiver will give trip (Unblock) output for 150 ms for this condition.

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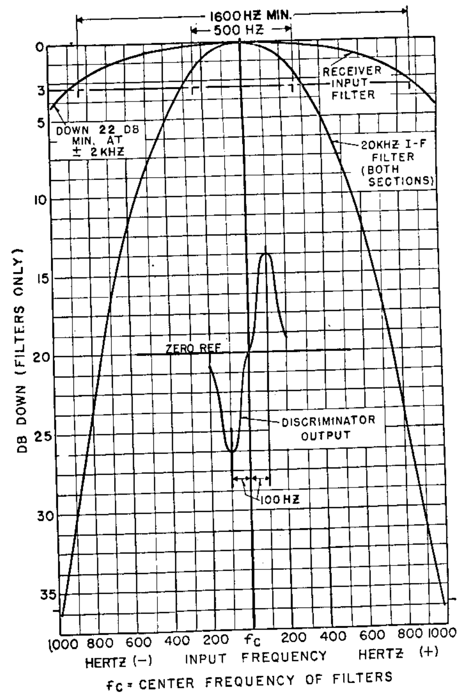
Fig. 3 Block diagram of output logic circuit



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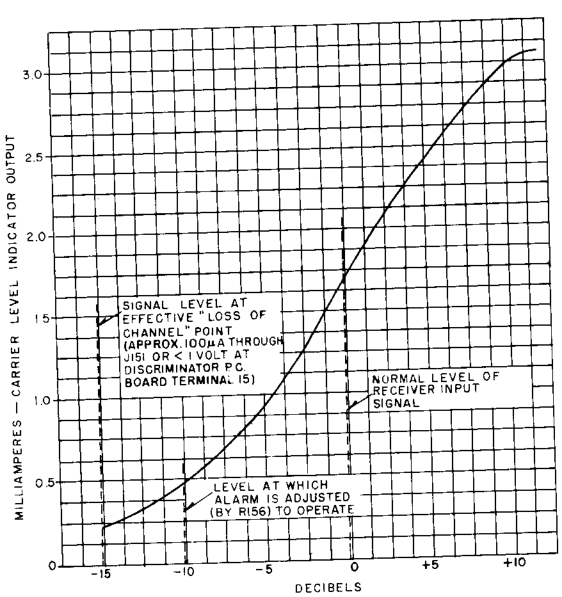

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Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

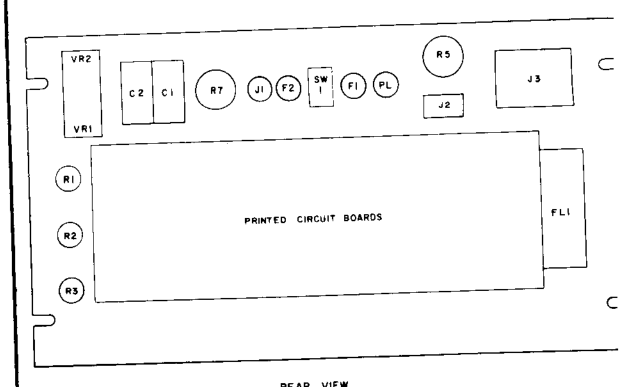

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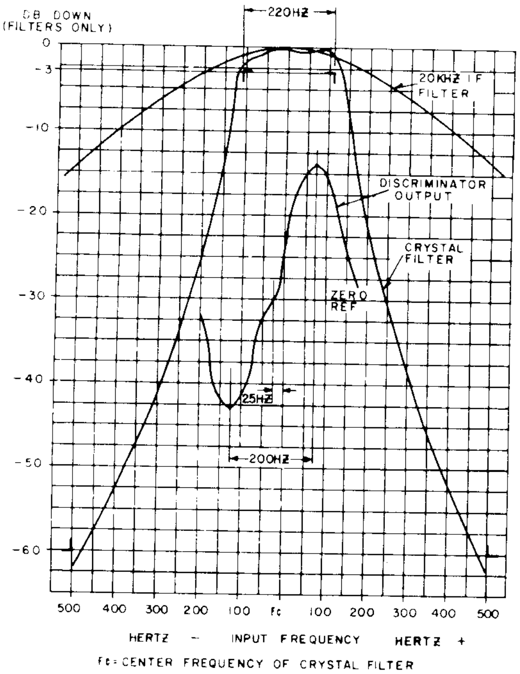
Fig. 6 Component locations on the type TCF receiver panel



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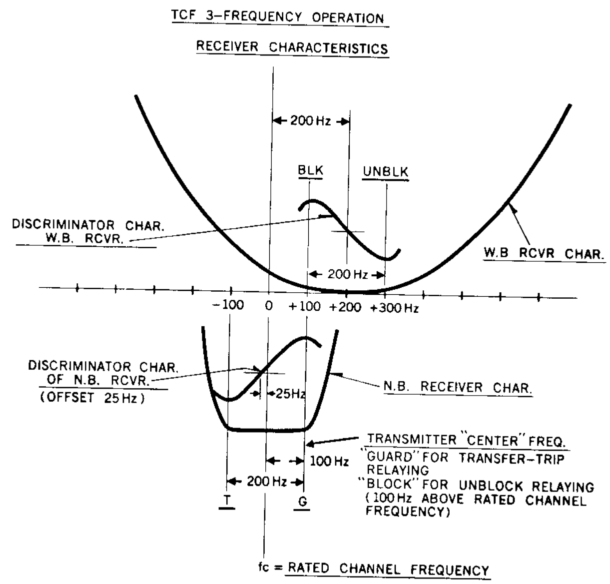


C 880A986

Fig. 4 Filter and discriminator characteristics of the type TCF receiver

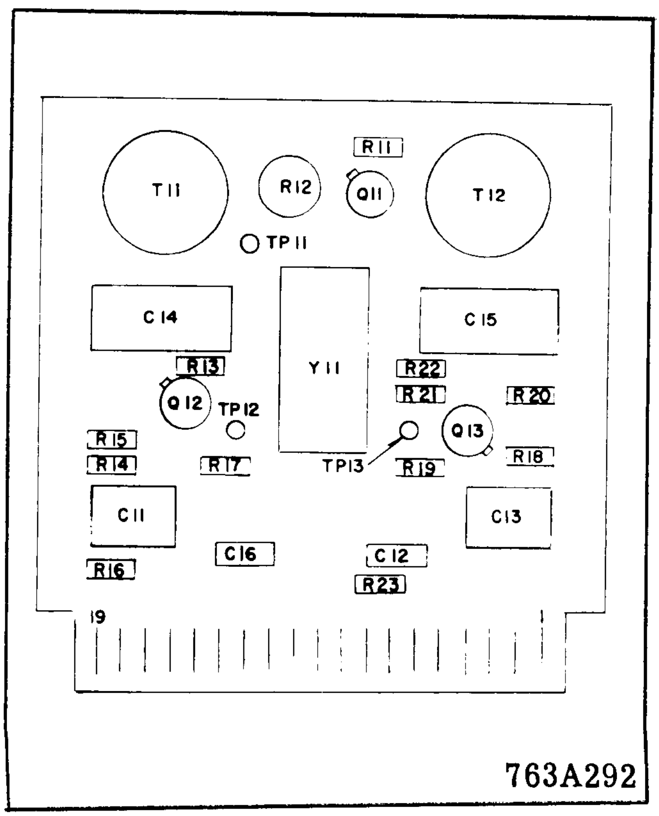


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

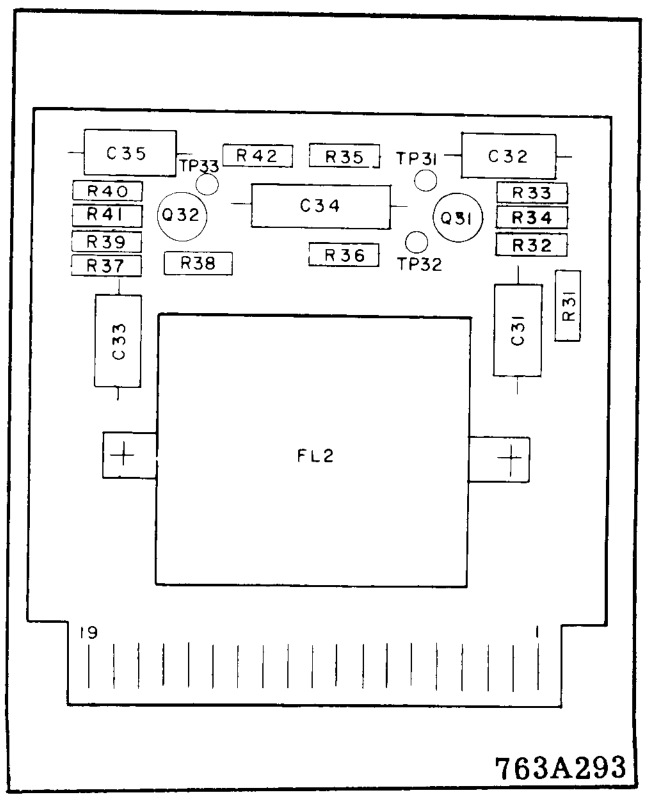


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

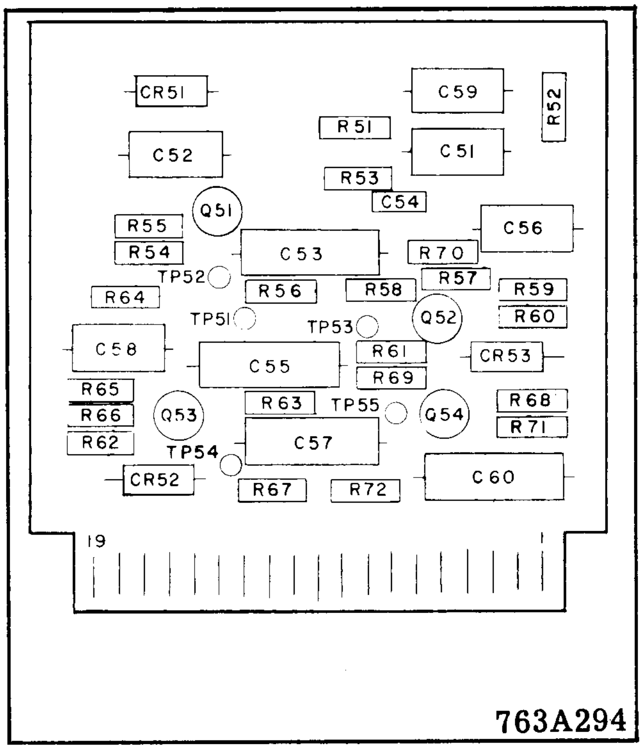


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

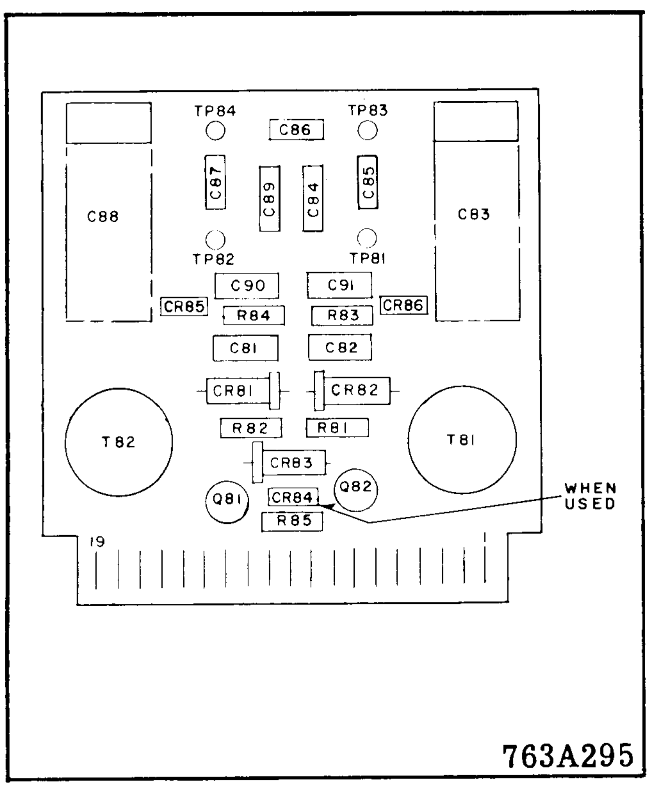


Fig. 10 Component locations on the discriminator printed circuit board.

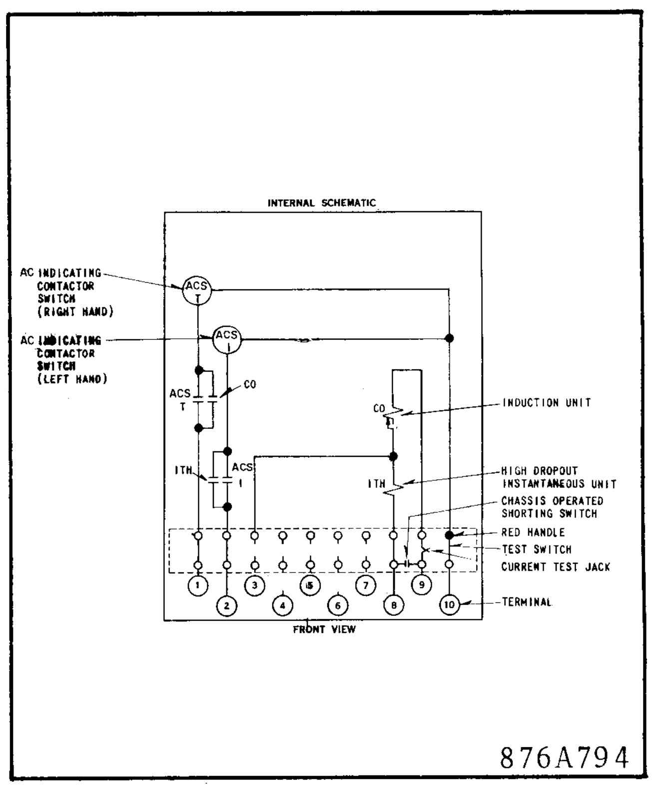


Fig. 11 Component locations on the logic printed circuit board.

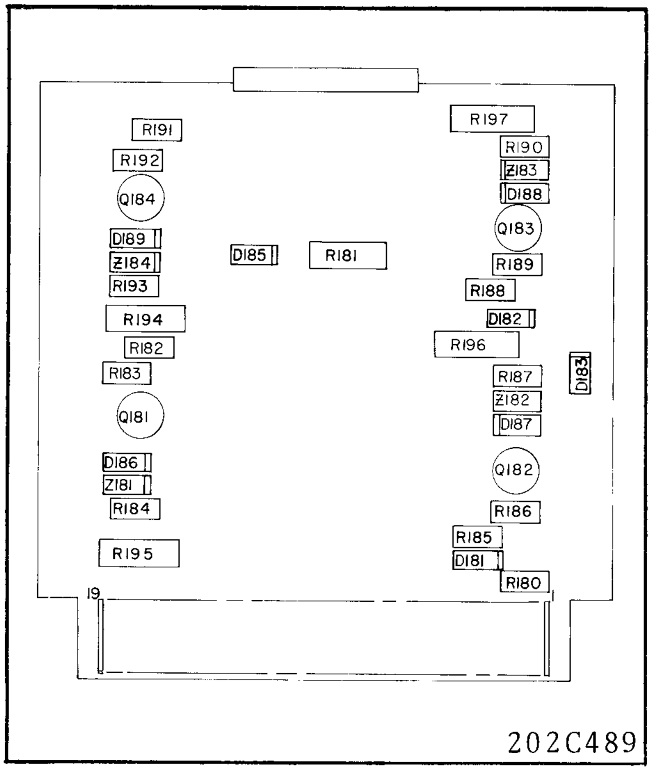


Fig. 12 Component locations on the output printed circuit board.

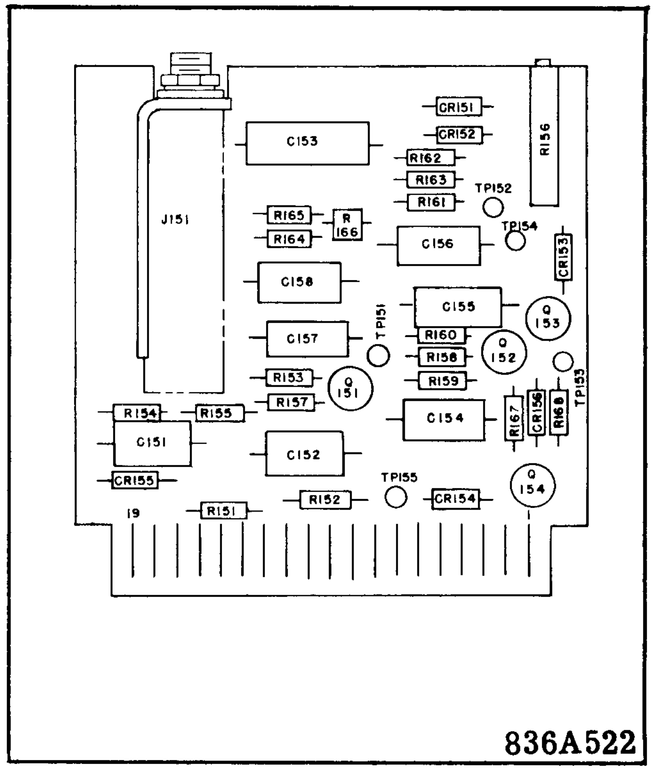


Fig. 13 Component locations on the carrier level indicator printed circuit board.

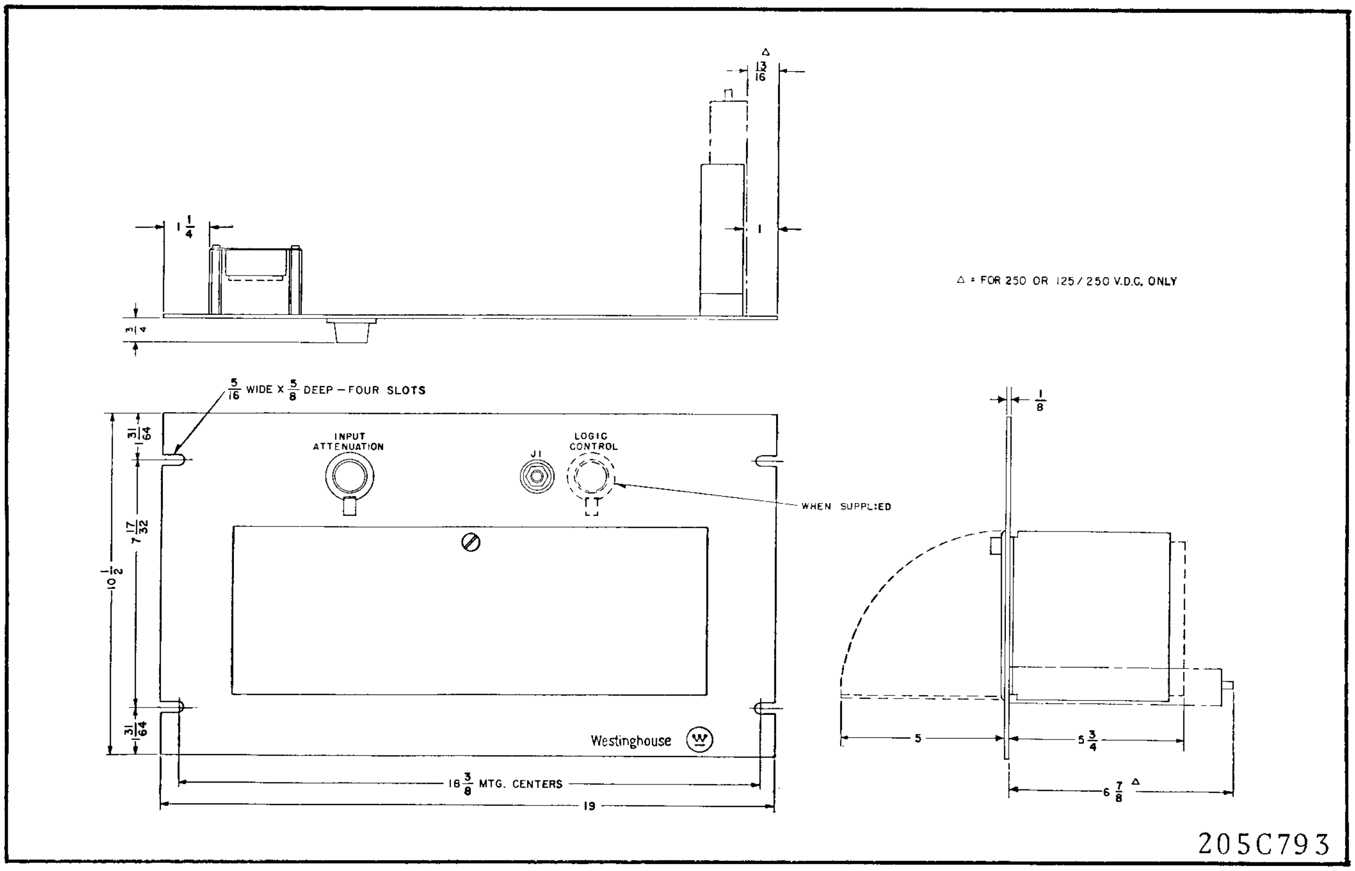


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

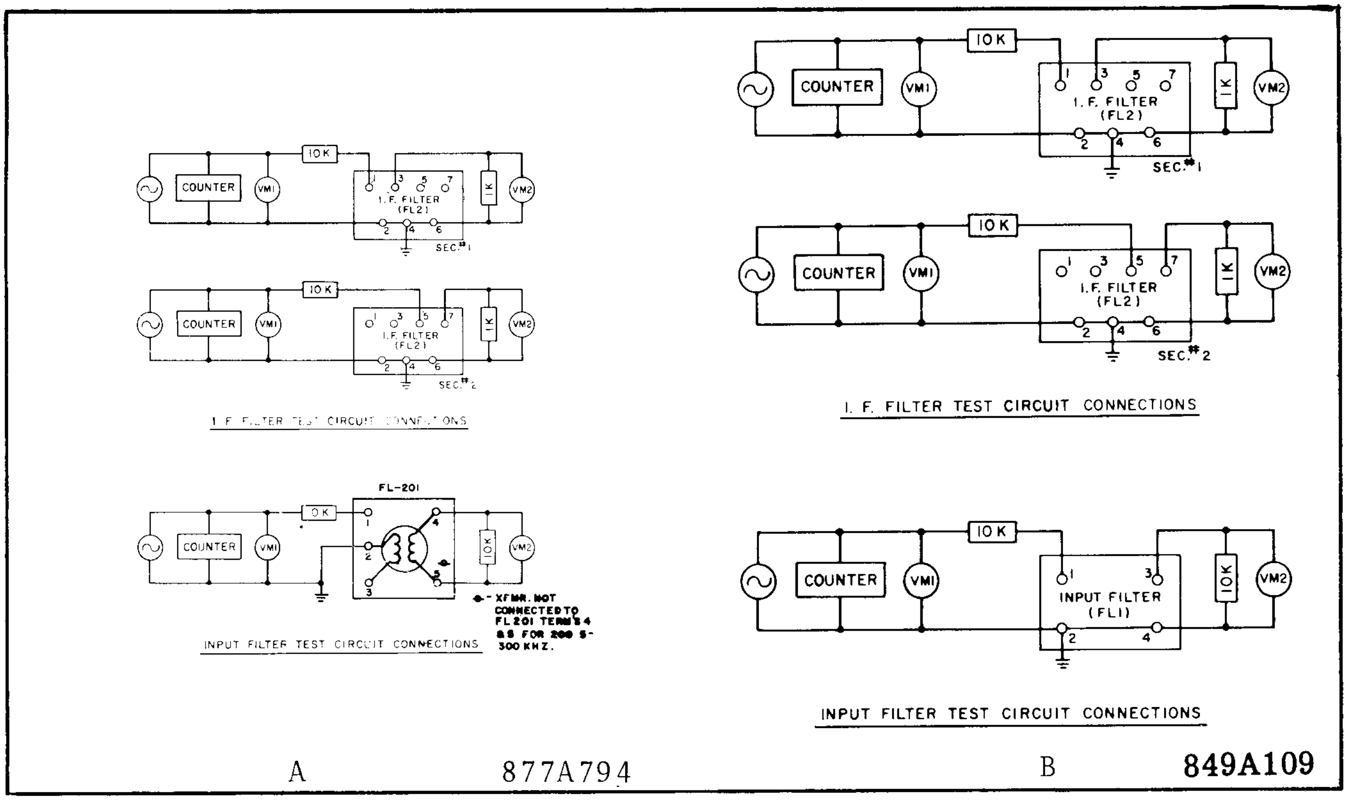


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

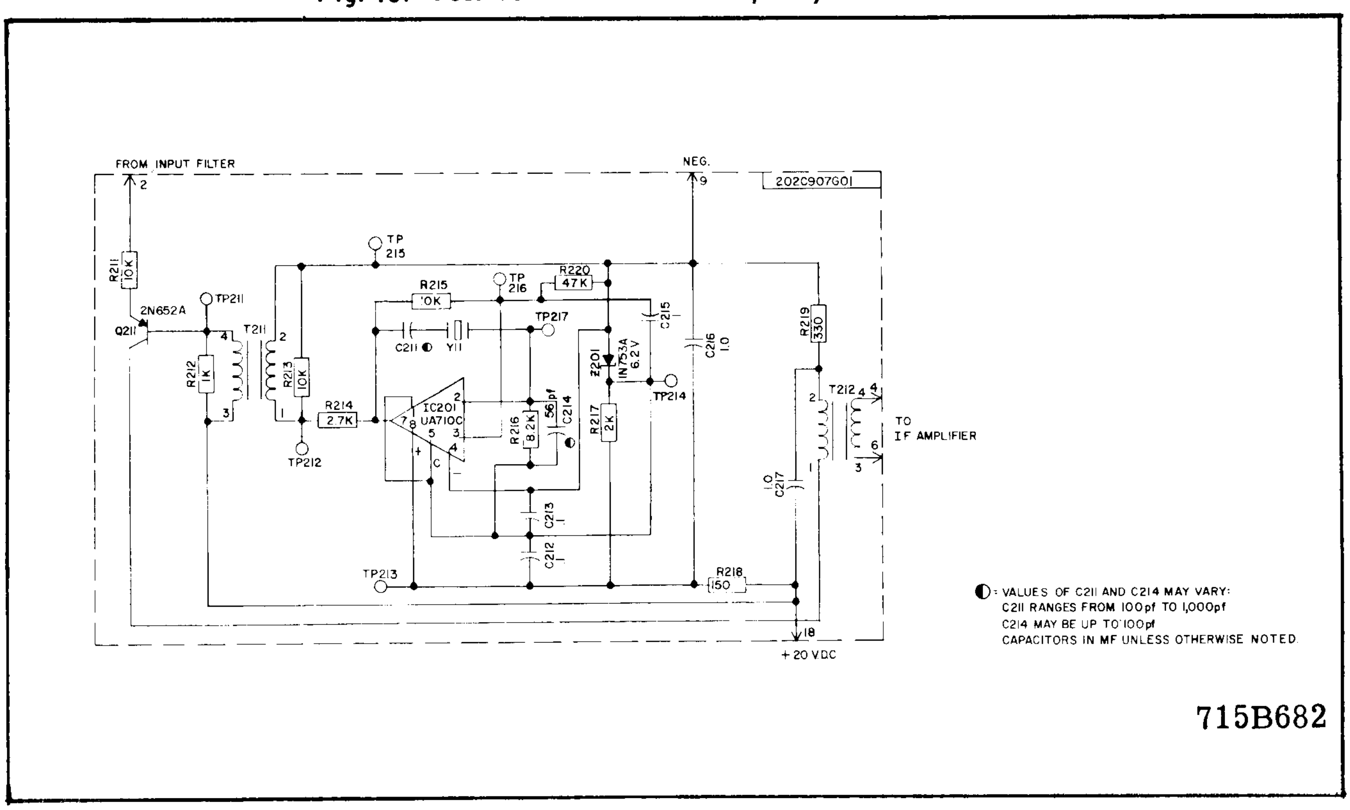


Fig. 16. 200.5 to 300 kHz oscillator mixer board

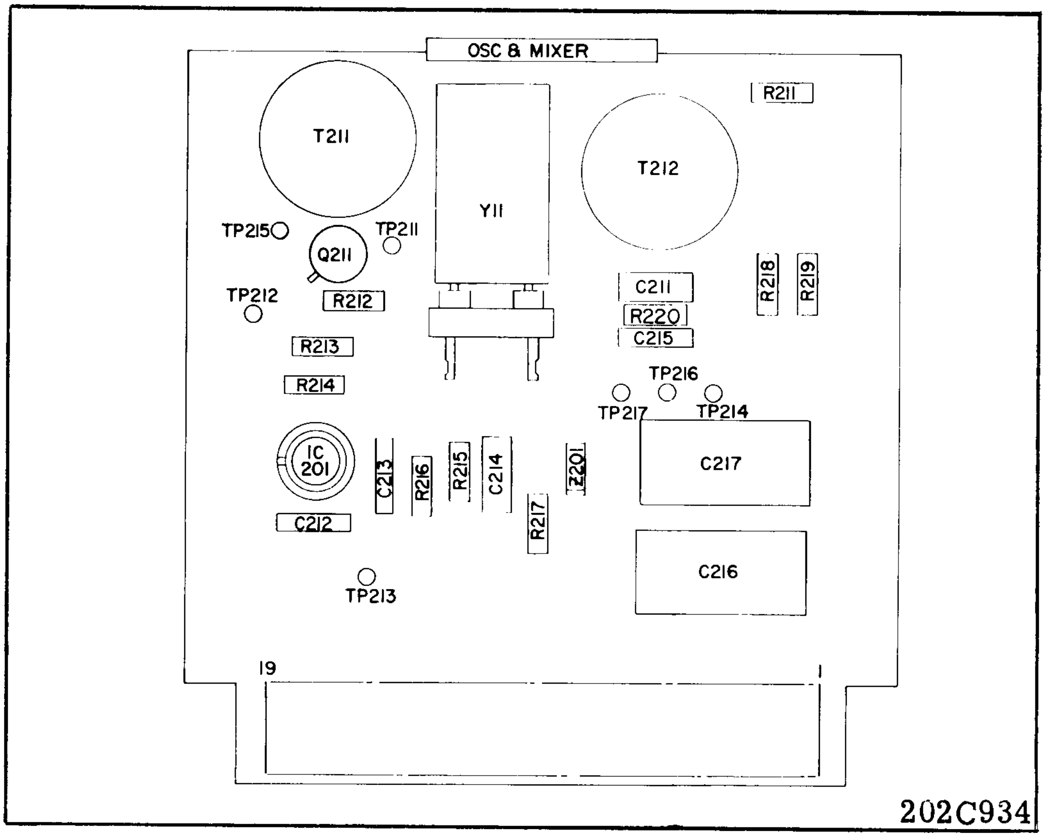
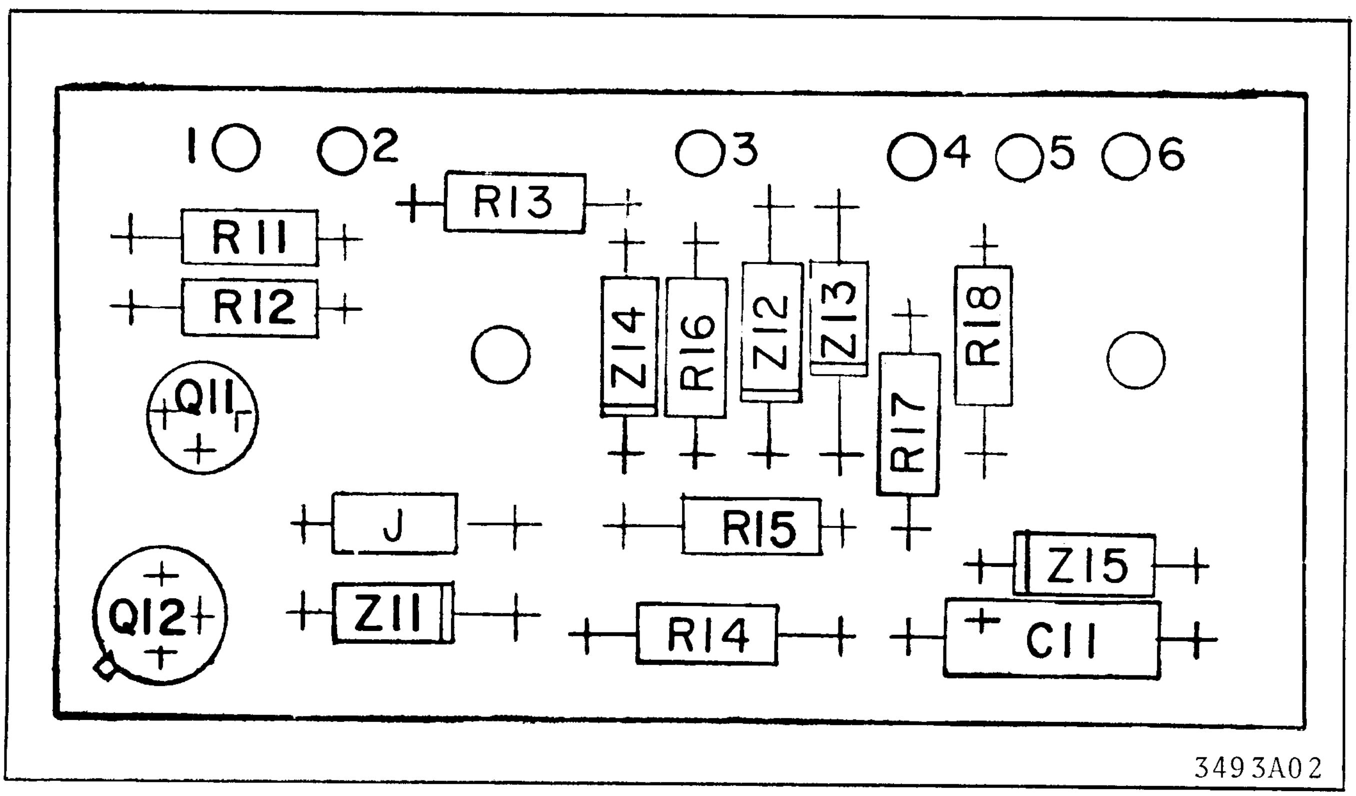


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.



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